The Modernization of the Aegis Fleet with Open Architecture

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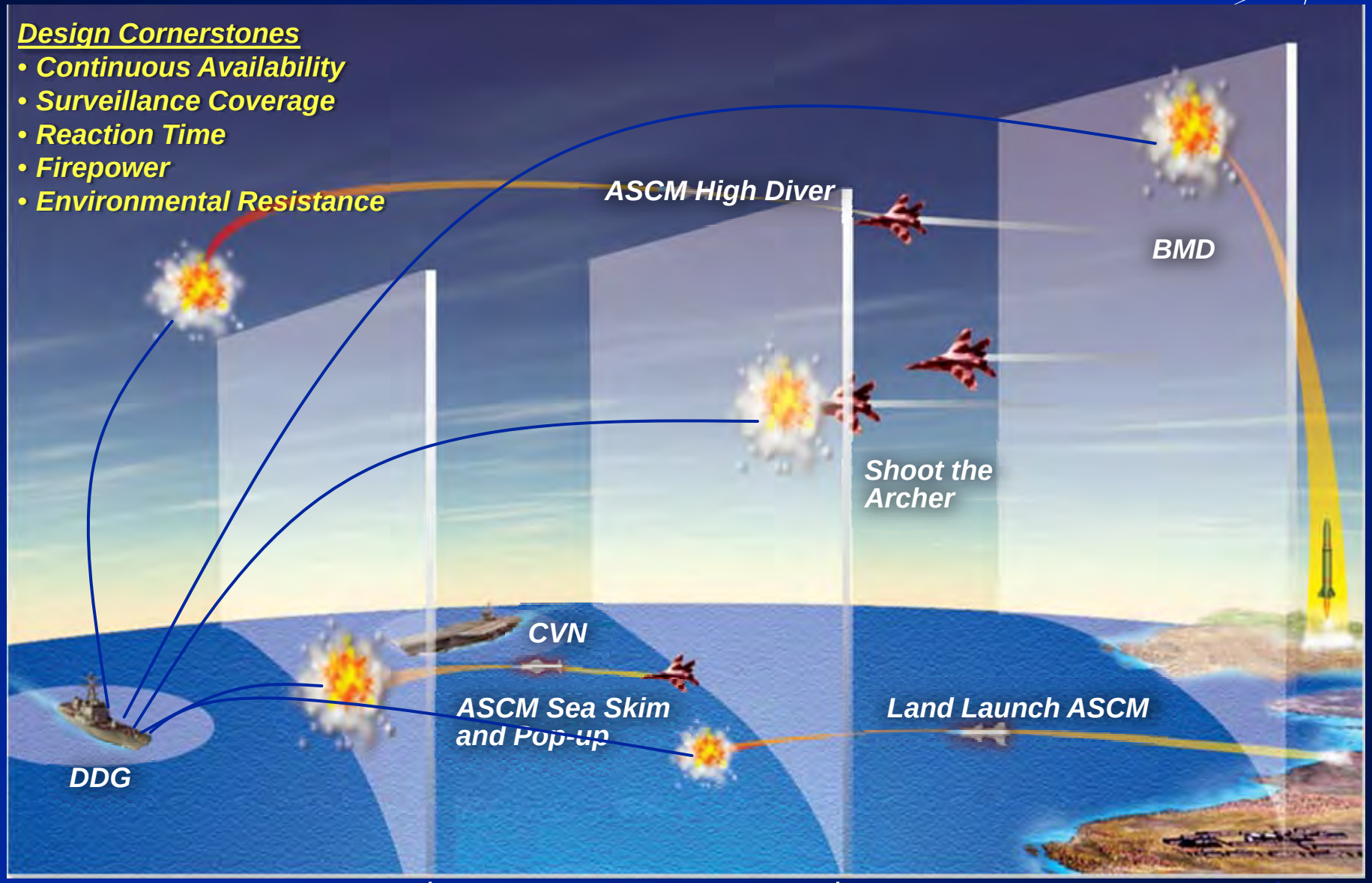
Topics

Things to talk about…

- **Background**
  - Aegis Overview
  - Capability Upgrade Evolution
  - Modernization Concept/Approach
- **Aegis Open Architecture**
  - Evolution to COTS Technologies and Products
  - Incremental/Spiral Development Approach
- **Aegis Modernization**
  - Overall Scope/Impact
  - Product Line Architecture
  - Integration of Common STM / TS Components
- **Summary**

Aegis – The Shield of the Fleet



Aegis Combat Systems Architecture

Aegis Display System

Radar System
AN/SPY-1

Command and
Decision System

Vertical Launching
System Mark 41

Fire Control System
Mark 99

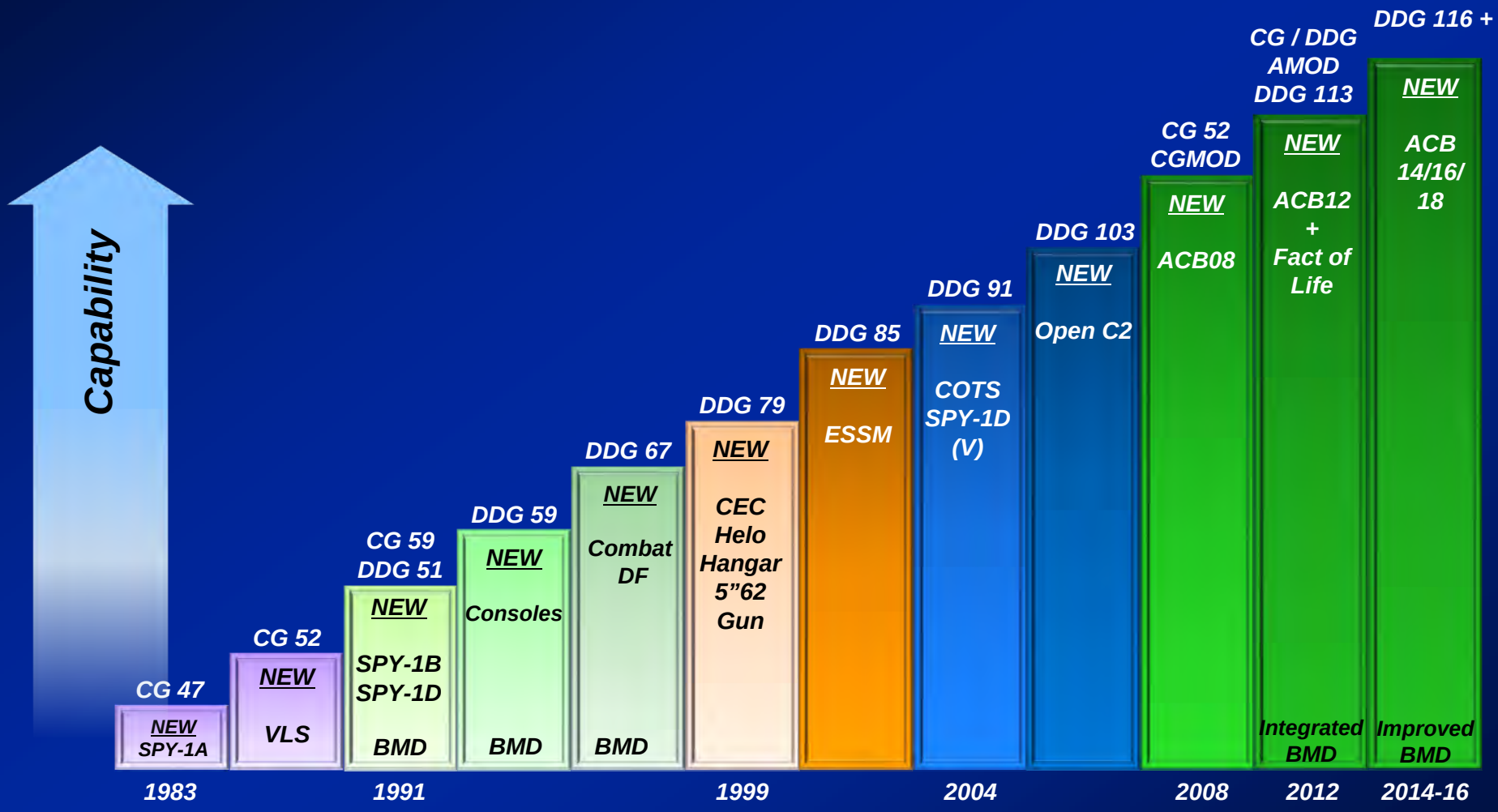
Standard Missile-2
SM-3
VLA
TLAM
ESSM

Weapon Control
System

Aegis Combat
Training System
Mark 50

Operational
Readiness
Test System

Aegis Capability Overview



12 Generations and Over 27 Years of Proven Success

Aegis Modernization Concept

I. Decouple Hardware and Software Upgrades Using COTS
   - Software Upgrades Every Two Years
   - Hardware Refresh Every Four Years

II. Build on Fielded Baselines

III. Integrate Navy Enterprise HW and SW Solutions

IV. Transition Aegis to Navy Objective Architecture

Benefits of Aegis Modernization Concept
- More Capability to the Fleet Sooner
- Foster Collaboration and Competition
- Cost Savings from Commonality & Reuse
- Minimal Lifetime Spares
- Upgrades Backward Compatible

COTS & Open Architecture -
While Maintaining Engineering Discipline

Aegis Open Architecture

AWS Computer Architecture Evolution

	B/L 1/2/3 CG 47-64	B/L 4/5 DDG 51-78 CG 65-73	B/L 6 Ph I/III DDG 79-90 CG 66 & 69	B/L 7 Phase I DDG 91-112	ACB08/TI08 CG 52-58	ACB12/TI12 CG 59+ DDG 51+
Fielding	1983	1990	1998	2005	2009	2012
COTS Selection			1994	1999	2006	2009
	 MIL Spec Design	 MIL Spec Design	 Mixed COTS and MIL Spec Design	 All COTS computers (MCE)	 All COTS computers (MCE)	 All COTS computers (MCE, CPS)
Processors	UYK-7 UYK-20	UYK-43 UYK-44	UYK-43/44+ Adjunct COTS	COTS	Mainstream COTS	Mainstream COTS
Software	CMS-2	CMS-2	CMS-2 C++, Ada	C++, Ada	Message-passing, Component-based C++, Java, Ada	Message-passing, Component-based C++, Java, Ada
Interfaces	NTDS Parallel	NTDS Parallel NTDS Serial	NTDS Parallel NTDS Serial FDDI / Ethernet	NTDS Parallel NTDS Serial FDDI**/ Ethernet	NTDS Parallel NTDS Serial Ethernet	NTDS Parallel NTDS Serial Ethernet
Displays	UYH-4	UYH-4 UYQ-21 (TGC*)	UYQ-21/UYQ-70	UYQ-70	UYQ-70 ORTS Thin Clients	CDS
System Complexities		UYK-43s B5PIII TGC	SMP's ALIS Network	All COTS SMP's Fast Ethernet	Open Architecture Mainstream COTS Gig-Ethernet	Open Architecture COTS MMSP Product-Line

* Applicable to Baseline 5 Phase III Only
** Eliminated in Baseline 7 Phase IR

COTS Technology and Products

Tech Insertion 00 2000

B7PhI

DDG 91-102

Tech Insertion 04 2004

B7PhIR

DDG 103-112

LCS / NCS - Derivative

Tech Insertion 08 2008

ACB 08

CG 52-59

Non-LM Hardware

- Computing Platform
- VME Single Board Computer
- Network Switching
- SAN Storage
- Network File System
- Thin Client LCD Display
- Analog Hardware/Devices

Non-LM Software

- Real Time Operating System
- Pub-Sub Communications
- High Availability Middleware
- Enterprise System Management
- Human-Systems Software
- Network Management Tools

Smaller Footprint and Reduced Processor Costs

Incremental Development

"Build a little ... test a lot"

At-Sea Demo
DDG 96

OA Radar

Spiral-1

Spiral-2

OA Display

OA Weapons

DDG 103-112

WSMR

Spiral-3

- Focused on Radar, Weapons
- Model-Centric Development (UML)
- Modern Languages (C/C++, Java)
- Non-Proprietary Interfaces

Tech Insertion 08

ACB 08

CG 52-59

2007

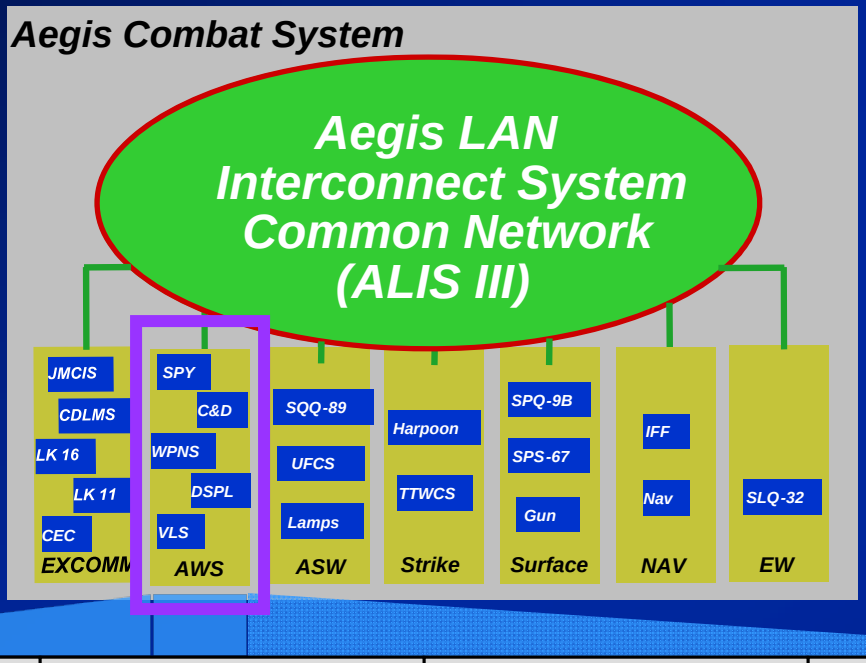
2008-2011

Completed Modular Designs

Fielding Modular Design foundation

Open Architecture Foundation for Baseline 9 Developments

Where We are Today



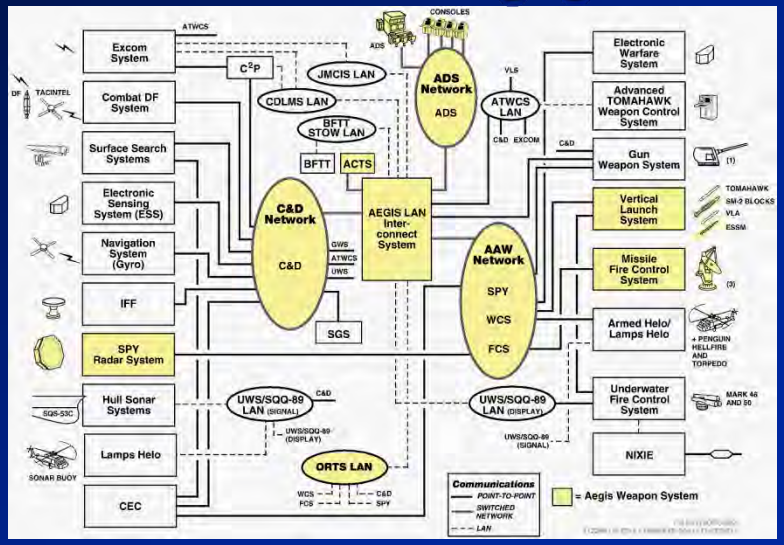
	Technical Assessment	SPY		Open C2		Weapons/ Fire Control	VLS
		Signal Processing	Radar Control	Display	C&D		
DDG-91 2004	Hardware	Custom	SMP	Mainstream	Mainstream	SMP	Mainstream
	Software	Closed	Closed	Open	Open	Closed	Closed
CG-52 2008	Hardware	Custom	Mainstream	Mainstream	Mainstream	Mainstream	Mainstream
	Software	Closed	Open	Open	Open	Open	Closed
CG-62/ DDG-51 2012	Hardware	Mainstream	Mainstream	Mainstream	Mainstream	Mainstream	Mainstream
	Software	Open	Open	Open	Open	Open	Open

Continuously Advancing the Aegis Combat System Forward

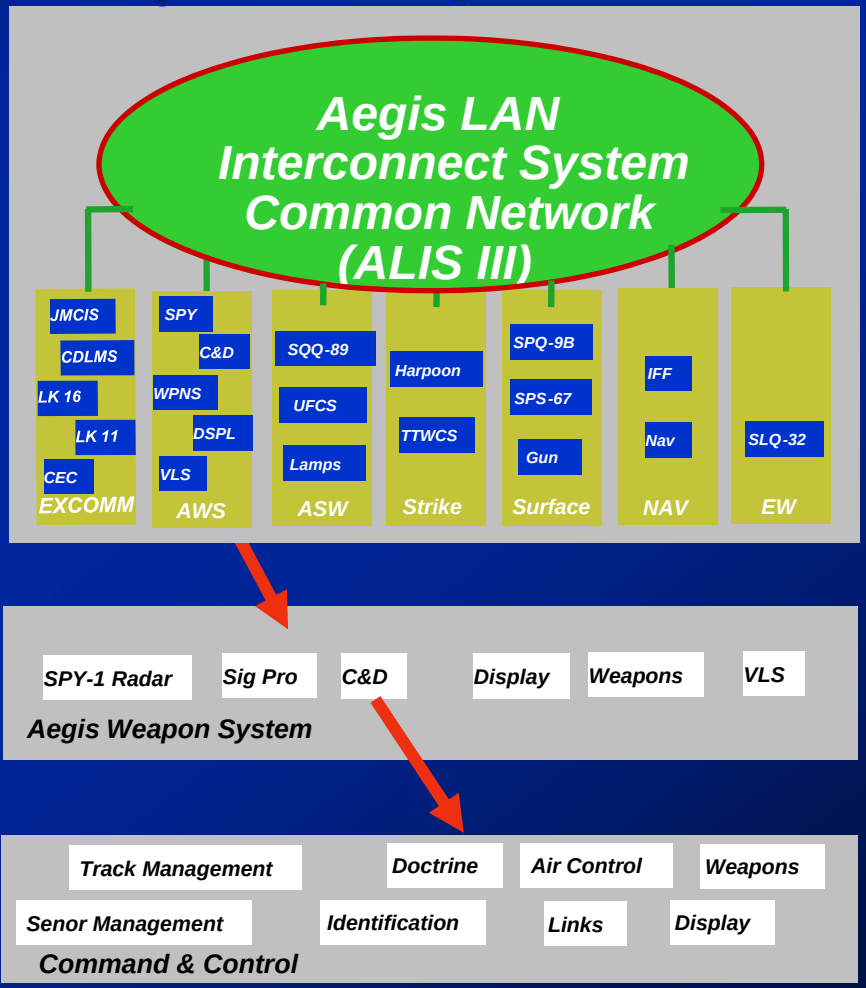
Today's Aegis Combat System

Surface Warfighting Electronics Architecture

Detect/Control/Engage View



System/Subsystem View

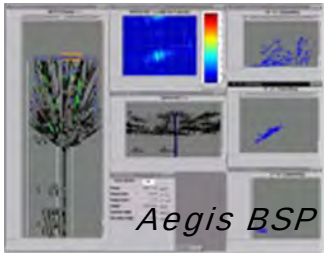


- ✓ **Federated, Tiered Architecture**
- ✓ **Efficient ACS Capability changes**
- ✓ **Well-Define Components and API's**

Supports Operational and Navy Business Model Objectives

Aegis Modernization

Roadmap to Aegis Modernization (AMOD)



Increased Battlespace and Multi-Mission Interoperability

AMOD Advanced Capability Build 12 (DDG configuration)

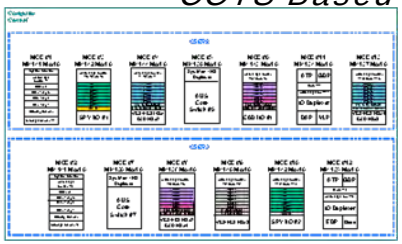
- ***Tech Insertion (TI) 12***
- ***ACS Element Upgrades***
- ***JTM Alignment***
- ***SM-6***
- ***Aegis BMD 5.0***
- ***NIFC-CA***
- ***MMSP***

AMOD Advanced Capability Build 12 (CG configuration)

- ***TI12***
- ***ACS Element Upgrades***
- ***JTM Alignment***
- ***SM-6***
- ***NIFC-CA***

AMOD ACB12 (TI12)

COTS Based Infrastructure



Aegis BMD 4.0.1

- ***Improved Discrimination***
- ***Improved Track Handover***
- ***Enhanced LoT***
- ***Integrated IR/RF KA***
- ***SM-3 Blk IA and IB***

ACB08

- ***OA Spiral 3***
- ***ACS Element Upgrades***
- ***TI 08***

CG MOD ACB08 (TI08)

Aegis BMD Block 06/08

Aegis BMD 3.6

- ***LRS&T, Engagement and LoT***
- ***Multi-Mission***
- ***Integrated Mission Planning***
- ***SM-3 Blk I and IA***

B/L 7 Phase IR

- ***OA Display Improvements***
- ***CIWS Block 1B Fratricide Avoidance***
- ***CEC 2.1 (Mode 5)***
- ***COTS Refresh 1***

B/L 7 Phase I

- ***COTS architecture***

Aegis BMD Block 04

CR0/CR1

AMOD Technical Scope

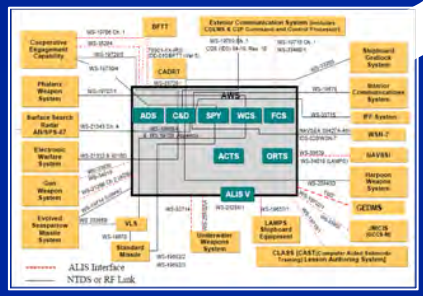
HM&E Upgrades

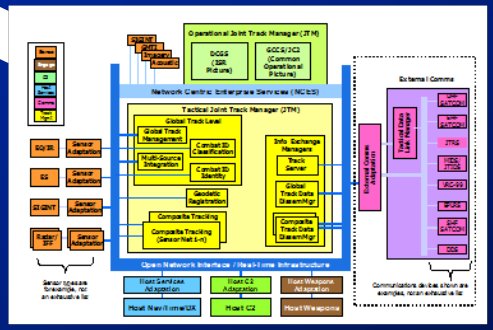
BMD 4.0.1 Functionality and SM-3

Aegis Weapon System COTS Refresh 3

NIFC-CA and SM-6

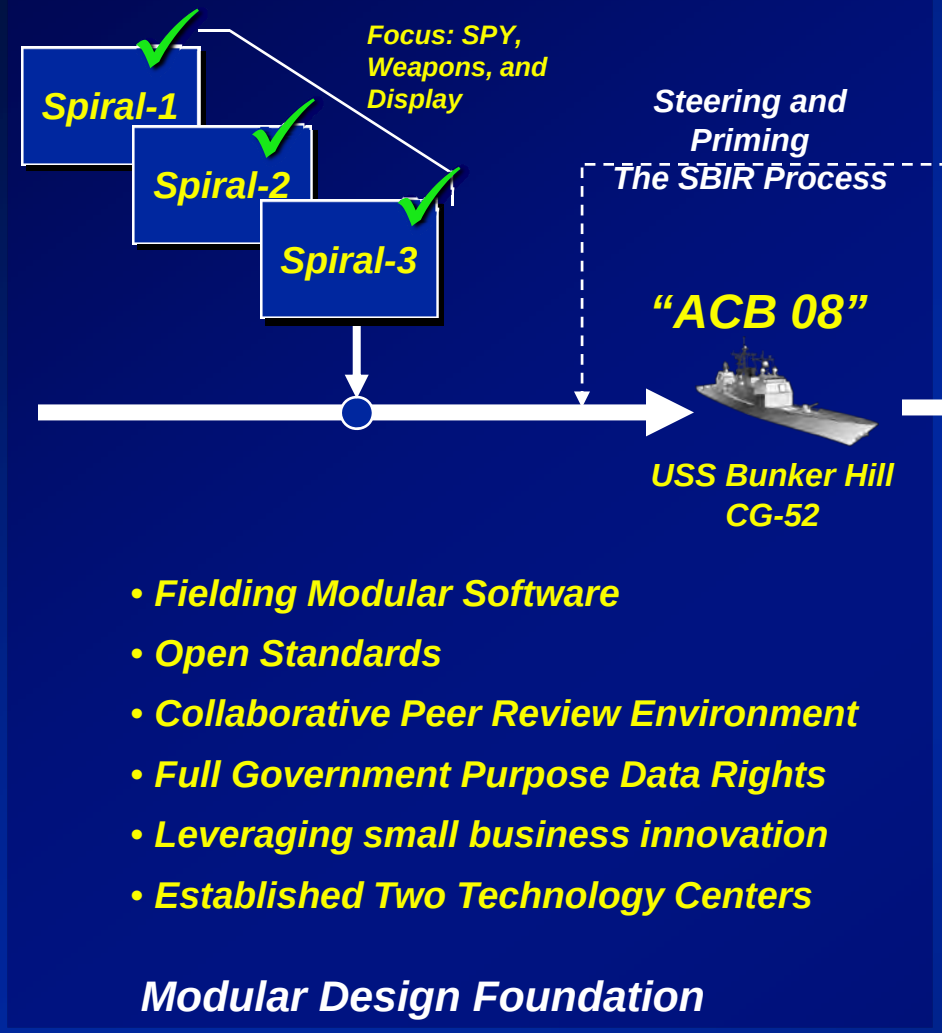
Aegis Combat System Upgrades

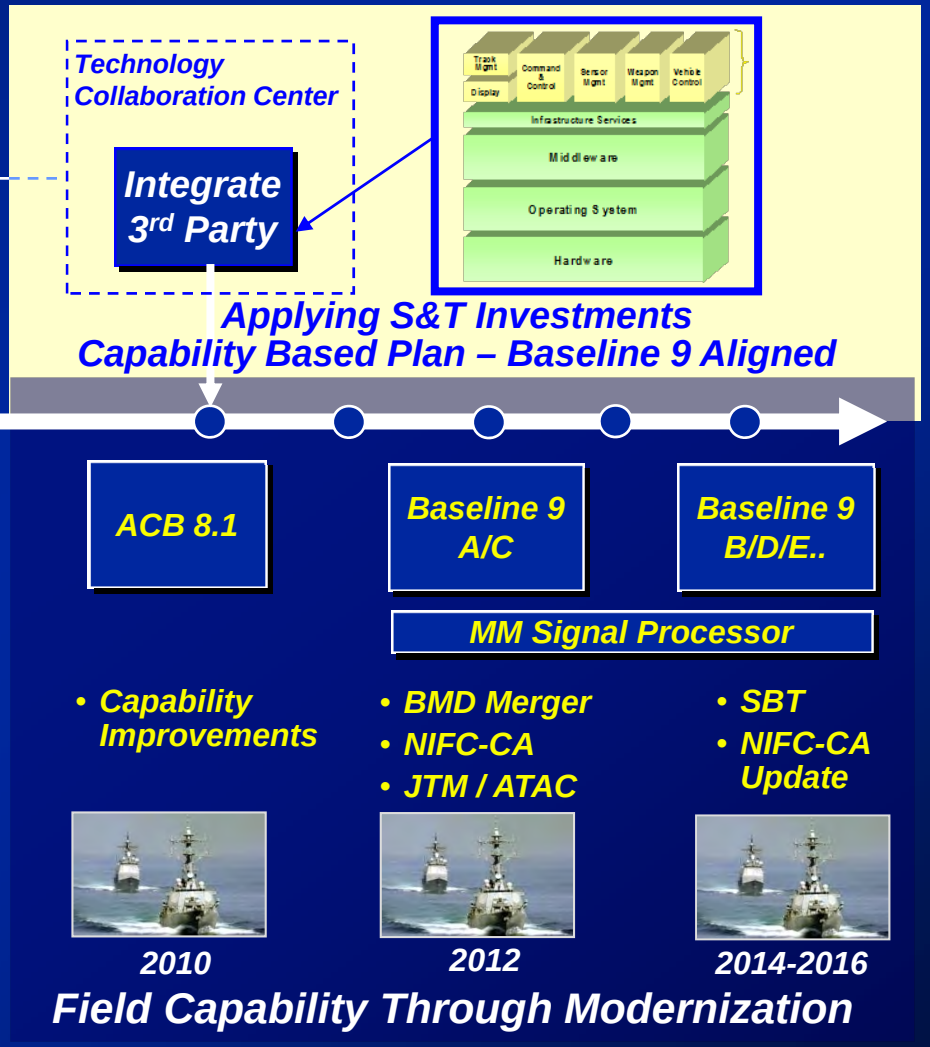




JTM Alignment

Way Ahead … Baseline 9





Balancing Capabilities with Complex Combat System Integration
Foundation Established for Transition to Objective Architecture

Implementing Open Architecture

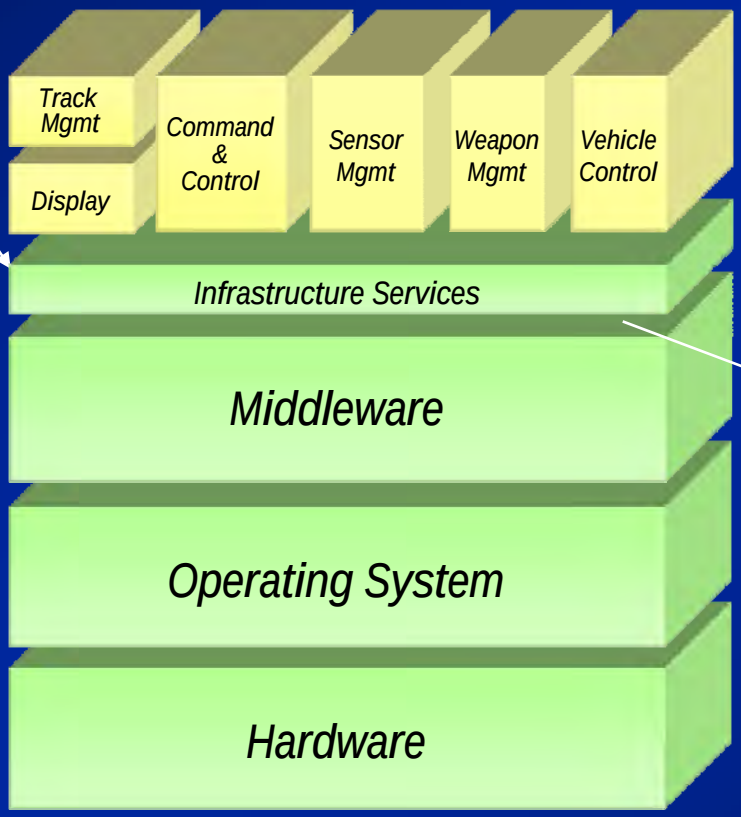
Layered Architecture Foundation

Infrastructure:

- Common Services and APIs
- Flexibility to Support Forward-Fit and Back-Fit

Common Computing Environment:

- Standards-based Interfaces to network
- Commercial Mainstream Products and Technologies



Componentized Objective Architecture:

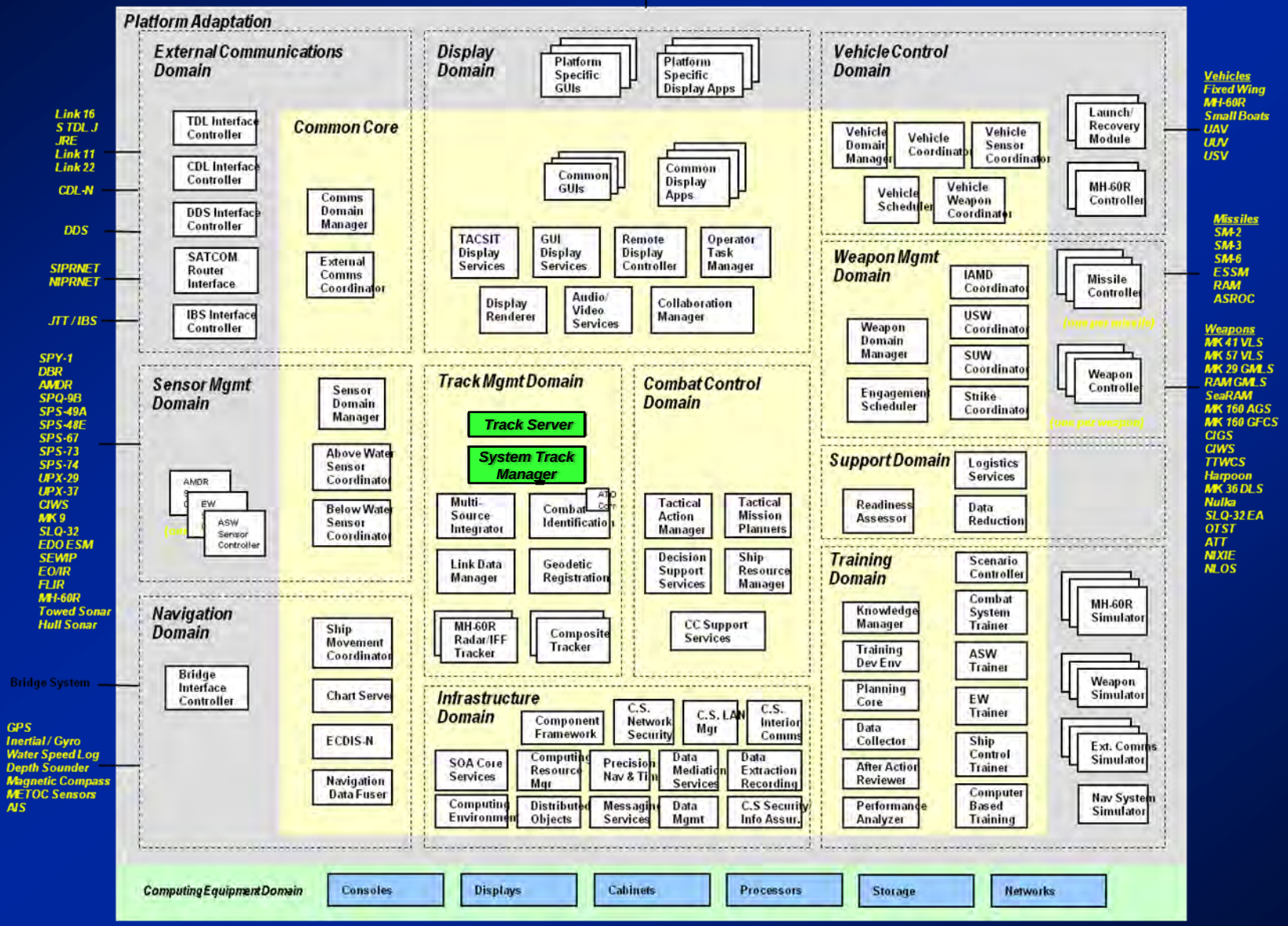
- Common Reusable Components
- Platform Specific Components
- Data Model
- Extensible to the Future

Decouple Hardware (H/W) from Software (S/W)

Upgrading Hardware and Software Independently

Top Level Objective Architecture

"Component View…"



Joint Track Management Alignment

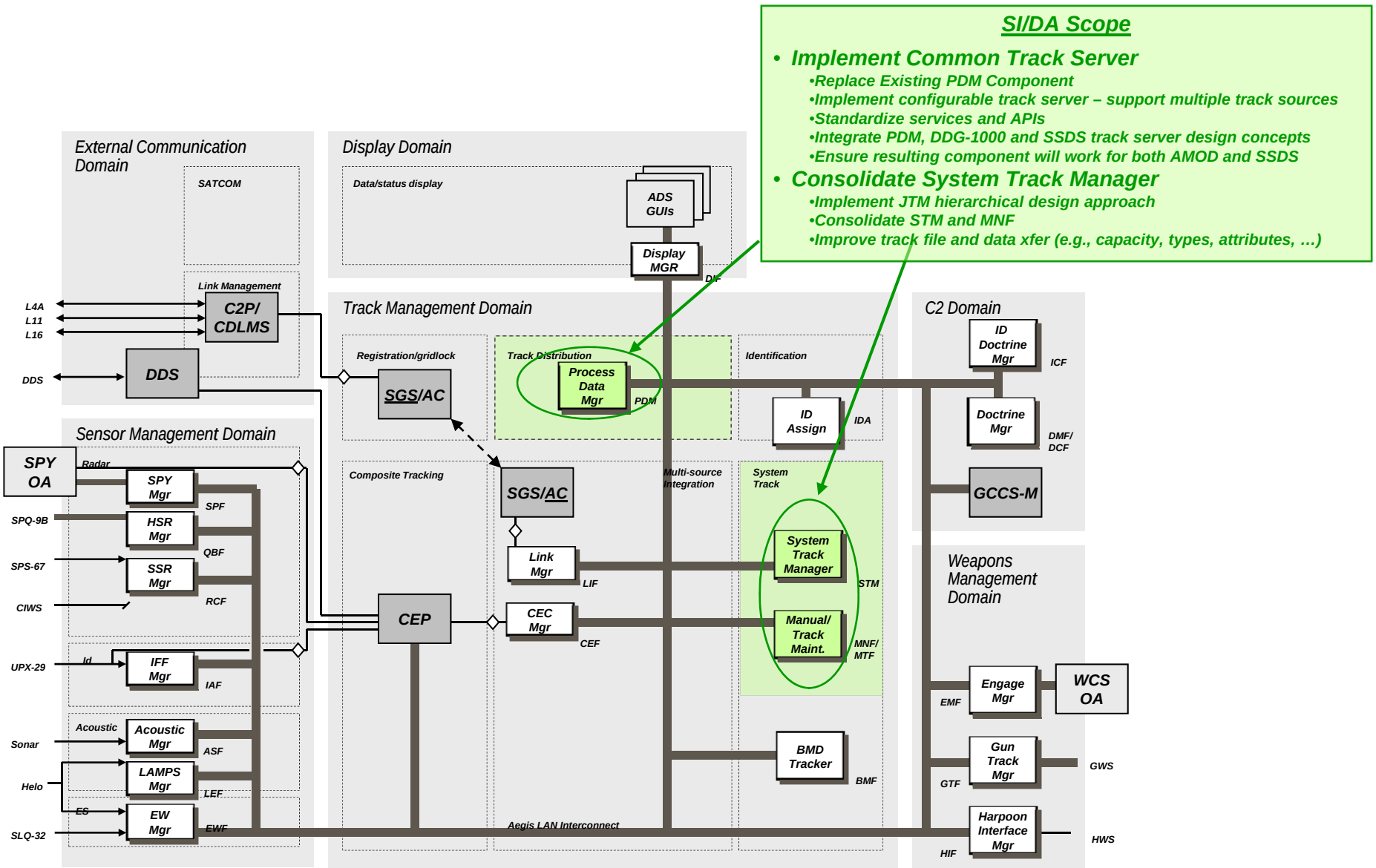
Overview

- **Align AMOD and SSDS Track Management to a Common Architecture**
  - Provide Consistent Functional Allocation, Data Representation and Attributes
  - Incorporate Reusable System Track Manager and Track Server Components
- **Provides Hierarchical Track File (System Level – Source Level)**
- **Provides Standard Interfaces**
  - Track Server Standard Access Interface for Client Applications
  - Track Manager Integrates Track Data Sources via Common Interface; Extensible for New Track Data Sources
- **Provides Two Complete Versions of Live Training Tracks:**
  - Allows Training Override of Multiple Attributes
  - Training Tracks Can be Physically Relocated From Live Location
- **Provides Dual Ownship – Tactical and Training:**
  - Allows Training View to be Repositioned with No Impact to Tactical View

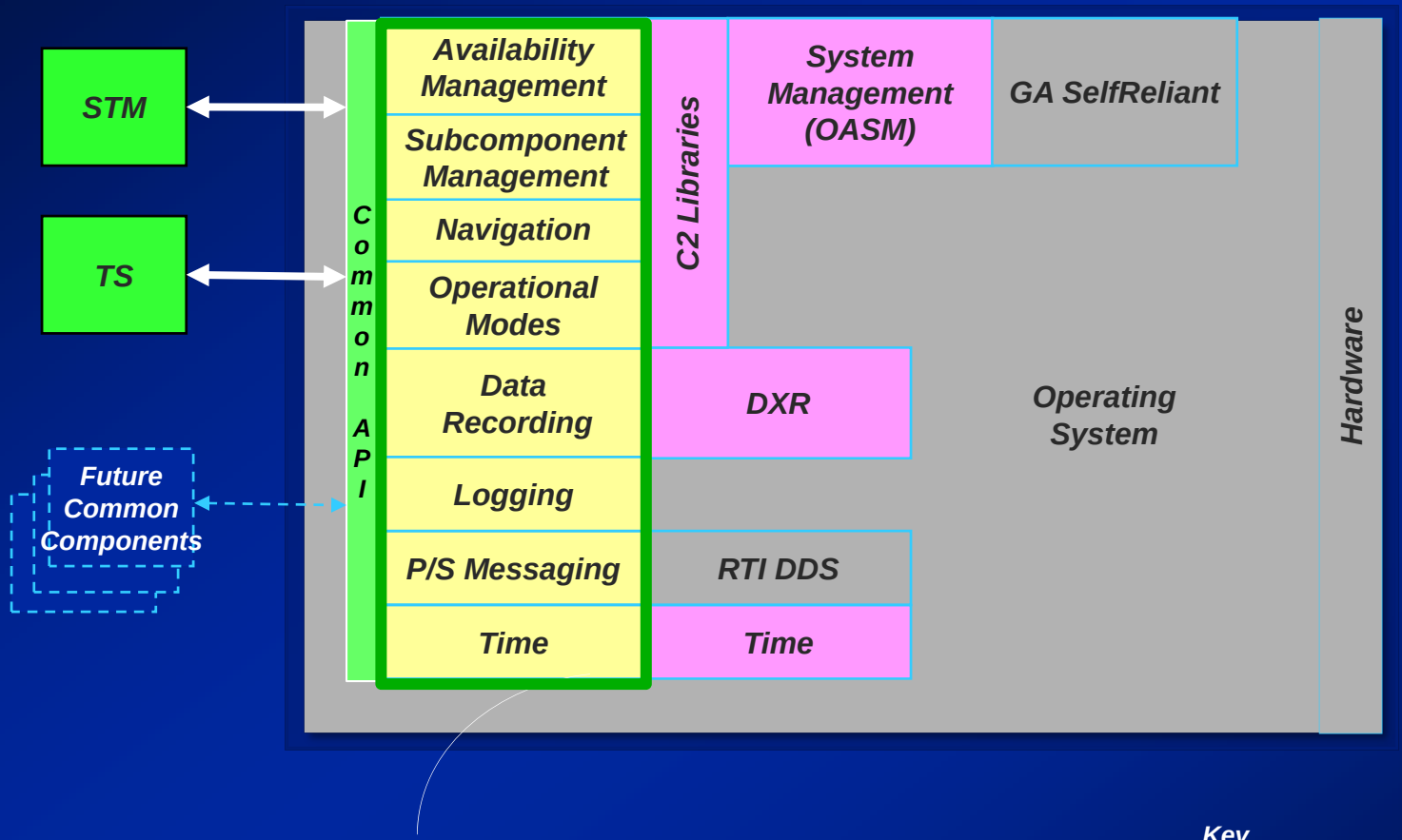
Aligning the Architecture for Future:
Common Components Across Ship Classes

JTM Alignment

Integration of Common STM and TS Components…



Component Framework Services

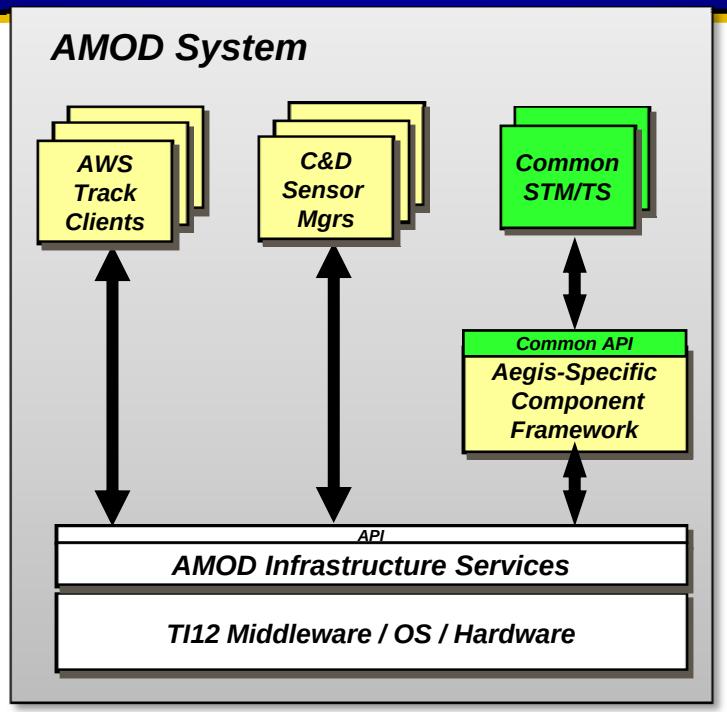


Common STM and TS Components

Task Allocation…

LM Tasks:

- *Update AMOD System Specs (A-level, B1, B5)*
- *Provide Legacy Aegis Requirements (e.g., STM, PDM, MNF) to SI/DA*
- *Validate Aegis Requirements Covered by Enterprise SRS's*
- *Remove STM/TS Functionality from Existing Components*
- *Modify C&D Sensor Managers IAW Functional Allocation (Design, Code, and Test)*
- *Modify Aegis Track Server Clients (Design, Code and Test)*
- *Design, Code and Test Aegis-Specific Component Framework*
- *Integrate STM/TS into AMOD*
- *Provide TOR/CPCRs*
- *Verify System Performance*



SI/DA Tasks:

- *Develop Enterprise SRSs for STM and TS from Aegis and SSDS*
- *Develop UML Models*
- *Auto-generate IDD and Interface Code from UML Models*
- *Design, Code and Test STM and TS Components*
- *Provide Interim and Final STM/TS Components to LM*
- *Implement CM and Change Control of STM/TS*
- *Implement CPCR Fixes to STM/TS Components*
- *Support Integration of STM/TS into AMOD*
- *Support SQT of STM and TS*

LM and Third party Joint Tasks:

- *Establish linked classified development environment*
- *Establish and Track Progress and Dependencies via Joint IMS*
- *Participate in Navy-led Data Model and Component Framework Working Groups*
- *Support Functional Allocation*
- *Support Definition of Data Model, TS APIs, and Common Service APIs*
- *Support Definition of Enterprise-level Processes and Artifacts*
- *Support Enterprise ETRs and Enterprise SSR*
- *Support Enterprise CCB and Prioritization/Adjudication of TORs/CPCRs*

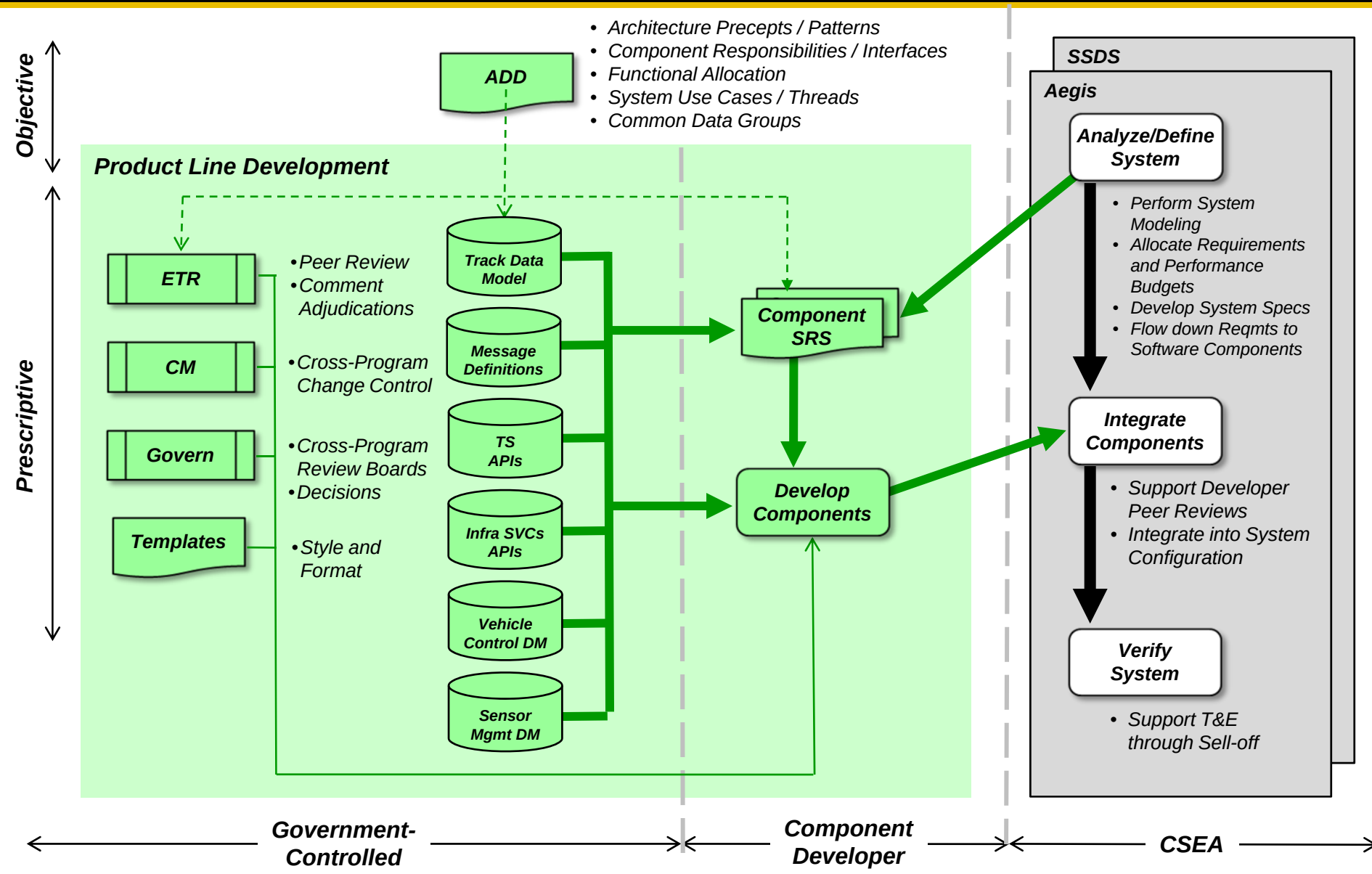
Legend

- New/Modified AWS
- New Common

Allocation and Governance Was Essential

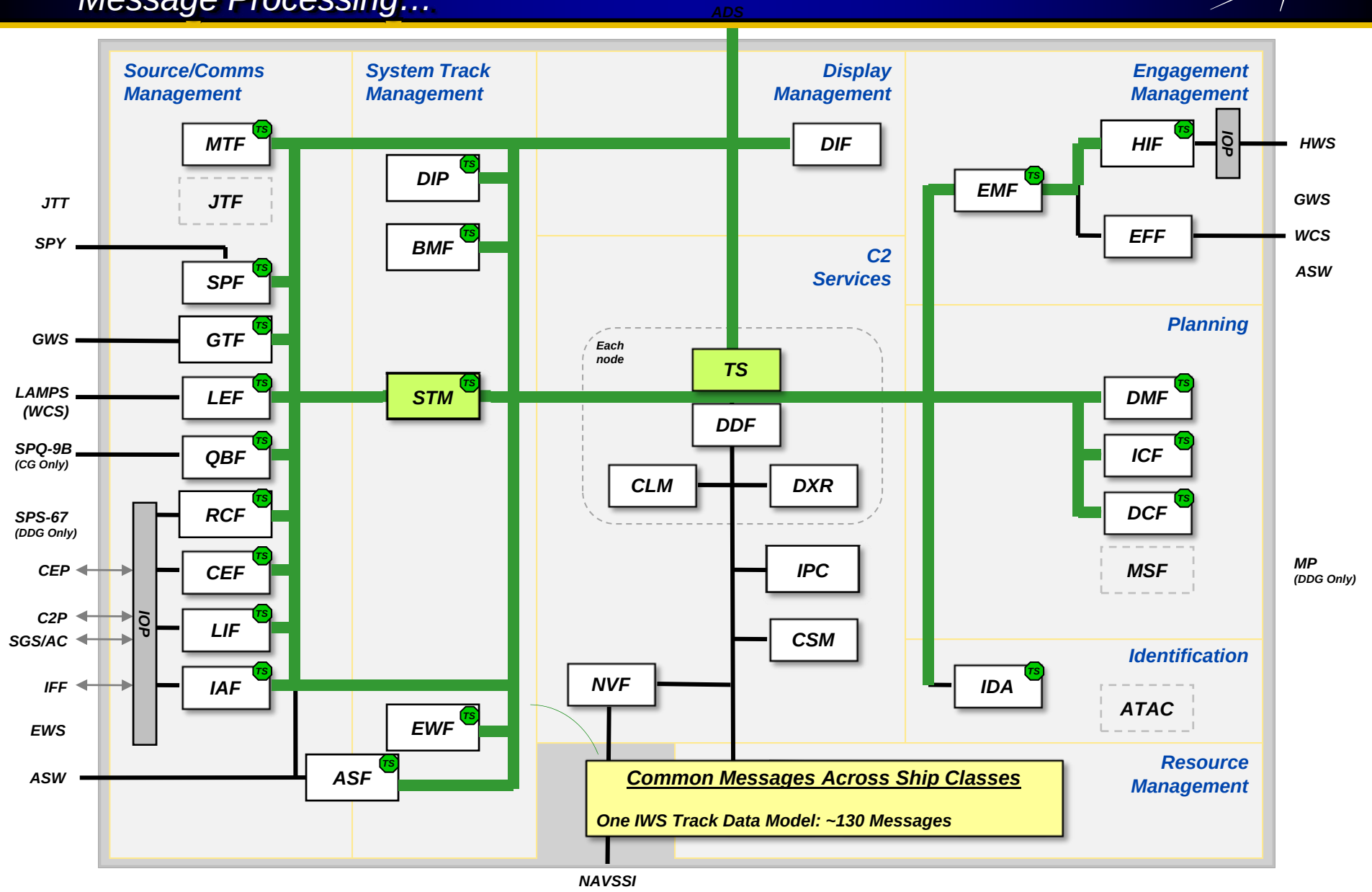
Objective Architecture

Roles and Responsibilities…



AMOD C&D Component Architecture

Message Processing…



What We Learned

- Documentation
- Design/Integration Tools
- Software Development
- Test Environment

- Skills / Expertise
- Organization

- Architecture
- Functional
- Performance

- Dependencies
- Risks
- Earned Value

Lessons Learned Address Multiple Perspectives

Aegis Open Architecture

Summary

1994 — 2000 — 2006 — 2012-2016

COTS Infrastructure

- Separation of Application/ Infrastructure
- Commercial Standards
- Commodity Products

B7PhI

DDG-91+

Component-Based Software

- Component-Based Designs
- Layered Architecture
- Configurable Test Environments

CGM

CG-52+

Open Business/ Common Components

- Objective Architecture
- Open Business Practices
- Open Disclosure / Gov't Purpose Data Rights
- Increase Number of Players/ Opportunities

AMOD

DDG-51+ / DDG 113

CG-62-73

Increased Capabilities

- AAW/BMD
- JTM
- SM-6
- NIFC-CA
- SBT

Glossary

Acronym	Description	Acronym	Description
ACB08	Advanced Capability Baseline 2008	**LAN**	Local Area Network
ACB12	Advanced Capability Baseline 2012	**LM**	Lockheed Martin
ACS	Aegis Combat System	**LOT**	Launch on TADIL
ADD	Architecture Definition Document	**MMSP**	Multi-Mission Signal Processor
Aegis	(not an acronym) Greek Shield of Zeus	**MS**	MicroSoft
ALIS	Aegis LAN Interconnect System	**NIFC-CA**	Naval Integrated Fire Control - Counter Air
AMOD	Aegis MODernization	**OA**	Open Architecture
API	Application Programming Interface	**OAET**	Open Architecture Enterprise Team
ASCM	Anti-Ship Cruise Missile	**OASM**	Open Architecture System Management
ASROC	Anti-Submarine ROCket	**P/S**	Publish/Subscribe
BL	Baseline	**PIDS**	Prime Item Development Specification
BMD	Ballistic Missile Defense	**PIM**	Platform Independent Model
C2	Command and Control	**PSEA**	Platform System Engineering Agent
CCB	Configuration Control Board	**PSM**	Platform Specific Model
CEC	Cooperative Engagement Capability	**Pub/Sub**	Publish/Subscribe
CG	Guided Missile Cruisers	**RF**	Radio Frequency
CIWS	Close In Weapon System	**SAD**	System Architecture Document
CM	Configuration Management	**SAN**	Storage Area Network
COTS	Commercial Off-the-Shelf	**SBT**	Sea-Based Terminal
CPCR	Computer Program Change Request	**SI/DA**	System Integrator / Design Agent
CR	COTS Refresh	**SM**	Standard Missile
CSEA	Combat System Engineering Agent	**SMP**	Symmetric MultiProcessor
CVN	Carrier Vessel Nuclear	**SQT**	System Qualification Test
DDG	Guided Missile Destroyer	**SRS**	System Requirements Specification
DDS	Data Distribution Service	**SSDD**	System/Segment Design Document
DM	Data Model	**SSDS**	Ship Self Defense System
DOORS	Dynamic Object-Oriented Requirements System	**SSR**	Software Specification Review
ESSM	Evolved Sea Sparrow Missile	**STM**	System Track Manager
ETR	Engineering Technical Review	**SVC**	Service
GCC	GNU Compiler	**SW**	Software
GFE	Government Furnished Equipment	**SysML**	Systems Modeling Language
HM&E	Hull, Mechanical and Electrical	**T&E**	Test and Evaluation
HW	Hardware	**TADIL**	TActical Digital Information Link
IAW	In Accordance With	**TI**	Technology Insertion
IDD	Interface Definition Document	**TLAM**	Tomahawk Land-Attack Missile
IDS	Interface Design Specification	**TOR**	Test Observation Report
IMS	Integrated Master Schedule	**TS**	Track Server
IPO	Input/Output/Process	**UML**	Unified Modeling Language
IR	Infrared	**VLA**	Vertical Launch ASROC
JTM	Joint Track Management	**VLS**	Vertical Launch System
KA	Kill Assessment	**XML**	eXtensible Markup Language